Drawings received and OK'd by Examiner. [signature] 2-10-04



*http://www.ntcresearch.org*, November 1998) was also developed to form fibers utilizing chaotic mixing. In particular, as shown in Figure 1, a continuous flow chaotic mixer 110 includes a fixed outer cylinder 112 and two rotating inner cylinders 114 and 116. Two polymers can be provided to the mixer by two conventional extruders 118 and 120. Within the mixer 110, the polymers can be blended by rotation of the cylinders 114 and 116.

Nevertheless, none of the above methods have been totally successful in fully controlling polymer blending to selectively form certain coherent structures (e.g., multi-layered films, fibers, interpenetrating blends, droplet dispersions, and the like) with desired characteristics, such as thin-layered, small diameter, etc.

As such, a need currently exists for an improved method of blending viscous fluids (e.g., polymers) and a method of controlling such blending to obtain certain coherent structures with desired characteristics.

## BRIEF DESCRIPTION OF THE DRAWINGS

A full and enabling disclosure of the present invention, including the best mode thereof to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures in which:

OK-1 Fig. 1 is a schematic view of a prior art continuous flow chaotic mixing device;

OK-2 Fig. 2 is a schematic diagram of one embodiment of a continuous flow chaotic mixing device that can be utilized in accordance with the present invention;

OK-3 Figs. 3A-3D are graphical illustrations representing the motion of a single particle within a melt during chaotic mixing according to one embodiment of the present invention;

OK-4 Fig. 4 is a graphical illustration of two polymer melt streams being formed into multiple layers within a chaotic mixer and extruded to form multilayer films according to one embodiment of the present invention;

OK-5 Fig. 5 is a graphical illustration of the progressive morphology development of three components into films, interpenetrating blends, fibers, and droplets;

OK-6 Fig. 6 is an SEM photograph of one embodiment of a multilayered film formed according to the present invention in which the blend was formed from 80% by volume polypropylene and 20% by volume ethylene-propylene-diene-monomer ternary copolymer (EPDM) and in which a cryogenic fracture surface separated the individual film layers;

OK-7 Figs. 7A-7B are SEM photographs of various embodiments of interpenetrating blends formed according to the present invention, in which Fig. 7A is a depiction of a polymer blend formed from polystyrene at 35% volume and low density polyethylene at 65% volume and Fig. 7B is a depiction of a polymer blend formed from polystyrene at 65% volume and low density polyethylene at 35% volume;

OK-8 Fig. 8 is an SEM photograph of one embodiment of an interpenetrating blend formed according to the present invention in which the blend was formed from 6.4% by volume low density polyethylene and 93.6% by volume polystyrene;

OK-9 Fig. 9 is a graphical representation of resistivity (ohms x meters) versus content of carbon black (wt.% of a blend containing carbon black and polystyrene) for various embodiments of the present invention in comparison to a prior art random mixing;

OK-10 Fig. 10 is an SEM photograph of one embodiment of a fiber blend morphology of the present invention in which the blend was formed from polystyrene at 91% volume and low density polyethylene at 9% volume;

OK-11 Fig. 11 is a graphical representation of the relative population of film, fibers, and droplets during chaotic mixing according to one embodiment of the present invention; and

ok -12 Figs. 12a and 12b are graphical illustrations representing embodiments of batch chaotic mixing devices that can be utilized in the present invention, in which Fig. 12a is a depiction of a primarily two dimensional batch chaotic mixing device and in which Fig. 12b is a depiction of a primarily three dimensional batch chaotic mixing device.

Repeat use of reference characters in the present specification and drawings is intended to represent same or analogous features or elements of the present invention.

## DETAILED DESCRIPTION OF REPRESENTATIVE EMBODIMENTS

Reference now will be made in detail to various embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment, can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations.

In general, the present invention is directed to a method of blending a major phase component with one or more minor phase components using chaotic mixing. In particular, it has been surprisingly discovered that by chaotically mixing two or more components in accordance with the present invention, blends having unique morphologies can be progressively and selectively formed. For example, two components can be blended in situ to form distributed multilayered film morphologies that may then be used in various applications or as a pathway for the development of other useful blend morphologies.

As used herein, the term “major phase component” refers to the component of the blend having the highest percent composition, while the term “minor phase component(s)” refers to any other components of the blend.